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US 4570227 A

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Online: WPI

(54) Personal navigation system

(57) A personal navigation system, particularly for use by the blind, combines signals from a satellite-based global positioning system, an electronic map (20), a route-planning algorithm (17) and a tactile display (29) associated with a speech synthesizer (26) (or a control handset associated with a speech synthesizer) to present the road features both around the position of the person using the system and the desired destination. A route to a desired destination can be indicated using a route-planning algorithm (17) and verbal navigation information regarding the current position of the user, the route and the destination can be output via a speech synthesizer (26).

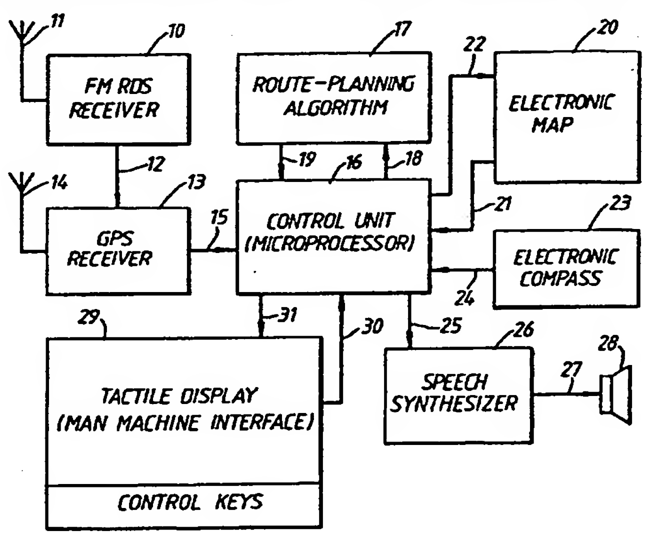

Fig.1

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

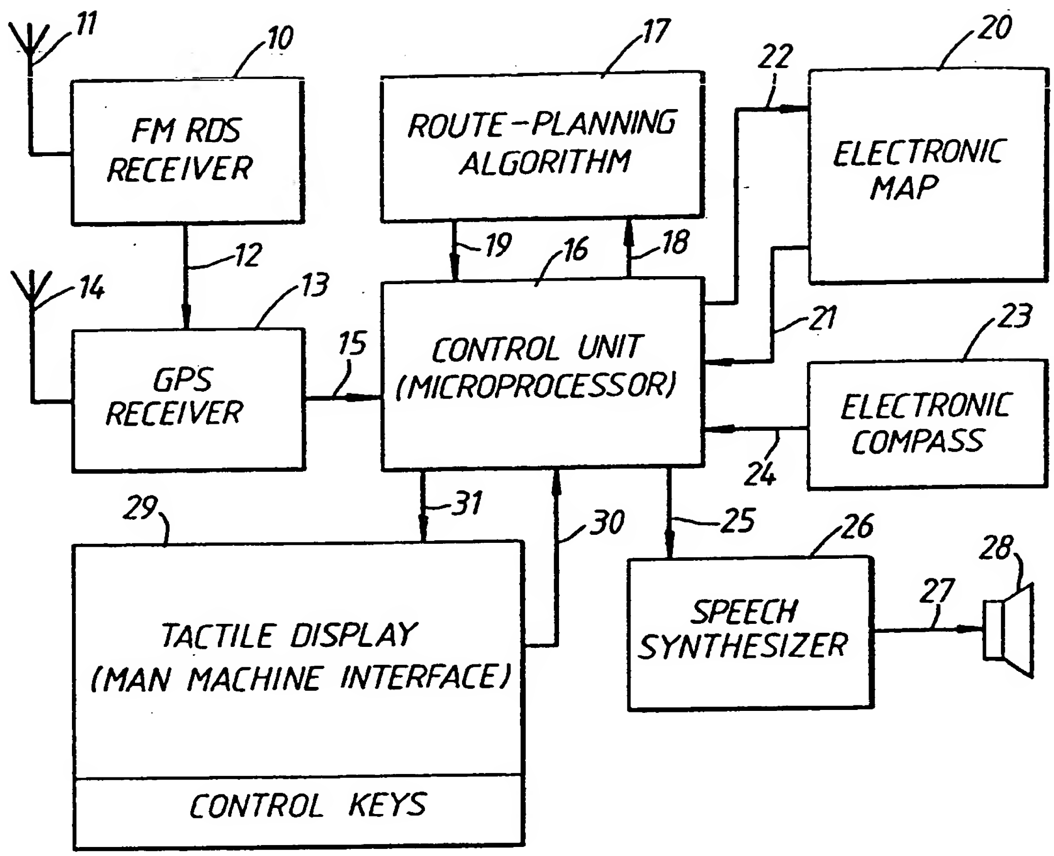
11
10
FM RDS RECEIVER
17
ROUTE-PLANNING ALGORITHM
22
20
ELECTRONIC MAP
12
19
16
18
14
13
GPS RECEIVER
15
CONTROL UNIT (MICROPROCESSOR)
21
23
ELECTRONIC COMPASS
24
29
31
30
25
26
28
27
TACTILE DISPLAY (MAN MACHINE INTERFACE)
CONTROL KEYS
SPEECH SYNTHESIZER

Fig.1

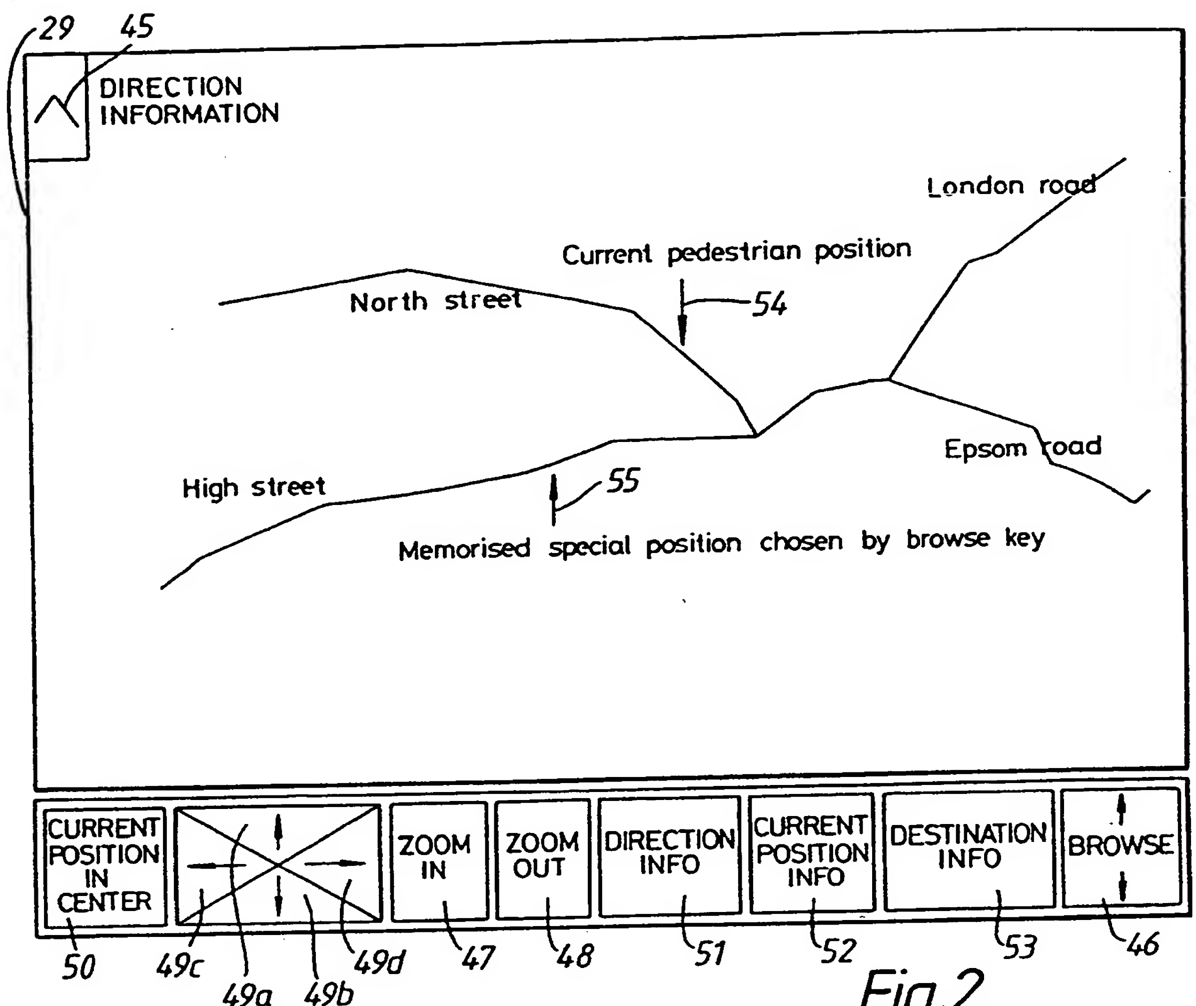
29
45
DIRECTION INFORMATION
London road
Current pedestrian position
54
North street
Epsom road
High street
55
Memorised special position chosen by browse key
CURRENT POSITION IN CENTER
ZOOM IN
ZOOM OUT
DIRECTION INFO
CURRENT POSITION INFO
DESTINATION INFO
BROWSE
50
49c
49a
49b
49d
47
48
51
52
53
46

Fig.2.

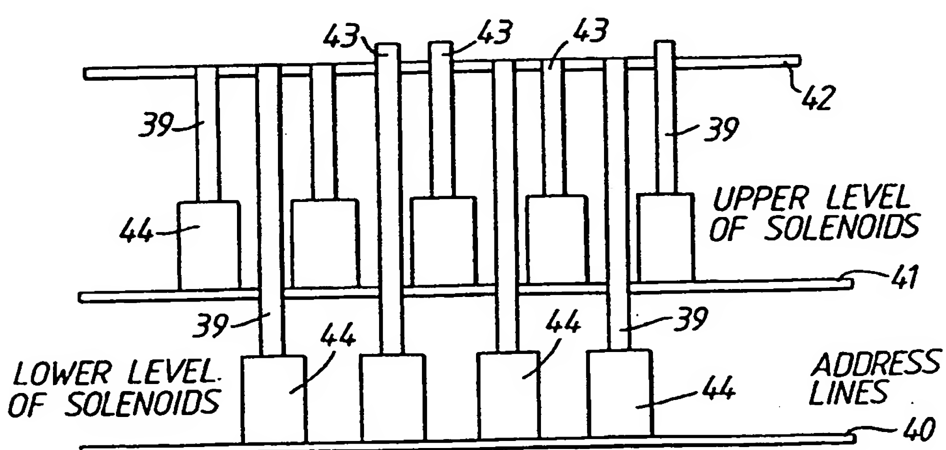
43
43
43
42
39
39
UPPER LEVEL OF SOLENOIDS
44
41
39
44
44
39
LOWER LEVEL OF SOLENOIDS
44
ADDRESS LINES
40

Fig 3

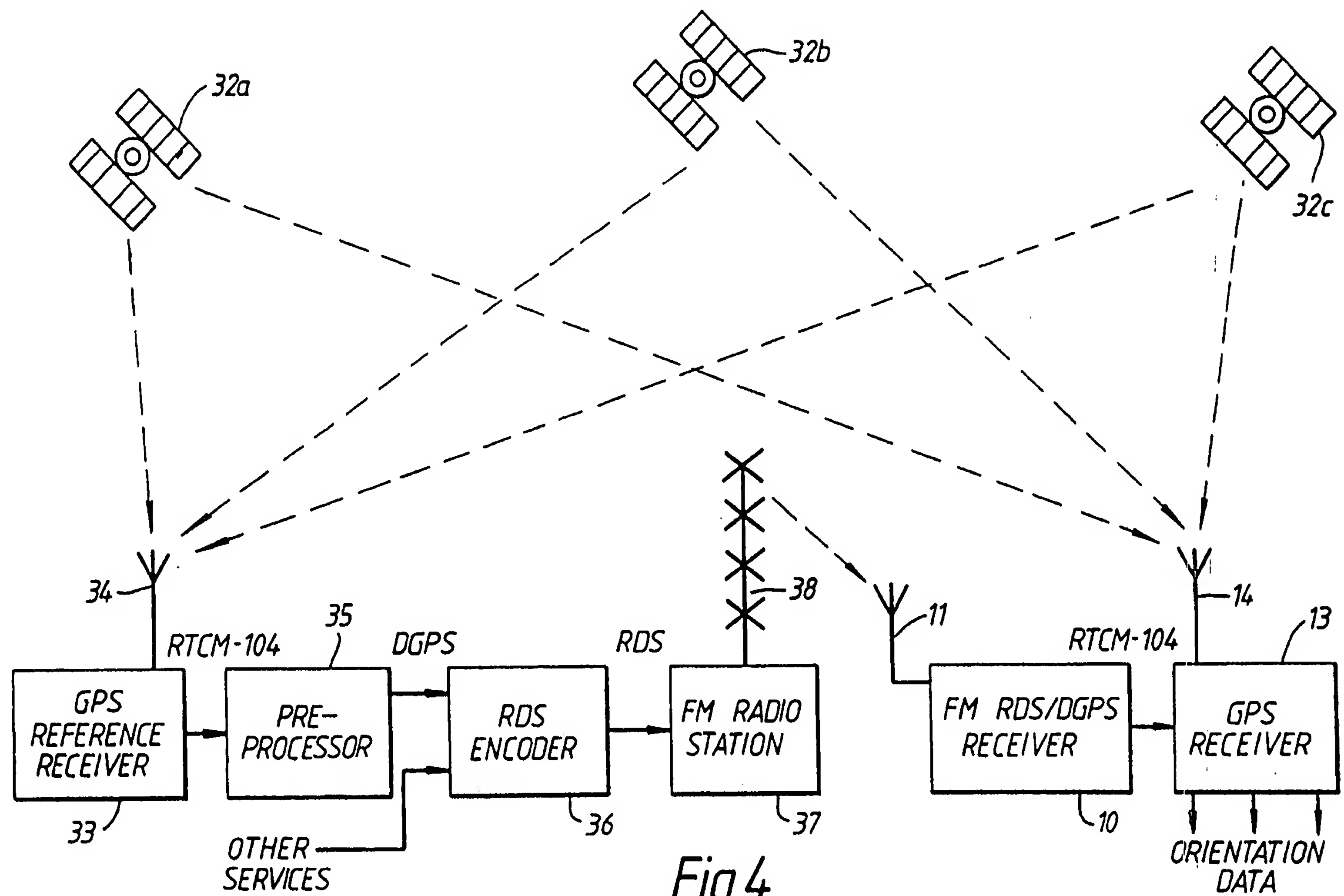
32a
32b
32c
34
RTCM-104
35
DGPS
RDS
38
11
RTCM-104
14
13
GPS
REFERENCE
RECEIVER
PRE-
PROCESSOR
RDS
ENCODER
FM RADIO
STATION
FM RDS/DGPS
RECEIVER
GPS
RECEIVER
33
OTHER
SERVICES
36
37
10
ORIENTATION
DATA

Fig.4

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PERSONAL NAVIGATION SYSTEM

The invention relates to personal navigation systems and particularly navigation systems for blind or partially-sighted persons. In this specification, the term "blind person" is to be taken as including both persons who are wholly without sight and partially-sighted persons.

In general persons navigate themselves either by a knowledge of the area in which they are travelling or by use of a map perhaps with a compass. There are also at present, several commercially available navigational aids for the blind traveller such as tactile compasses, raised dot maps, light probes and sonar systems. However, none of these systems have the ability to indicate the current position of the person in relation to the topological information given by the system.

According to the invention, there is provided a navigation system comprising a receiver for receiving a position signal transmitted thereto from a remote position signal generator, said position signal representing the instantaneous position on the globe of the receiver, and user interface means holding feature information regarding the spatial disposition of features of an area of the globe including said position, said interface means being connected to said receiver for receiving

from said receiver a signal representative of said instantaneous position, and producing perceivable information derived from the spatial relation between said instantaneous position and at least some of said features of said area.

Said interface means may provide a perceivable representation of the spatial disposition of said features of said area and said production of said perceivable information may comprise providing on said representation a perceivable indication of the spatial disposition of said instantaneous position.

Where the system is for blind persons, said interface means preferably includes a display means on which the representation and the indication are provided, said representation and said indication being perceivable by touch.

Preferably said interface means includes a memory means for storing electronic data representing the spatial disposition of said features, said interface means converting said electronic data into said perceivable representation on said display means.

Said interface means preferably includes a control unit for receiving said signal from the receiver and said electronic data from the memory means, the control unit using said signal and said data to generate a control signal for controlling the

display means whereby to produce thereon said representation and said indication.

The system may be adapted for producing on said perceivable representation a further perceivable indication indicative of the spatial disposition of a desired position lying on the globe spaced from said instantaneous position, a calculating unit being provided for producing from said signal from the receiver, said electronic data and from positional data representing the spatial disposition of said desired position a signal indicating a route between said instantaneous position and said desired position.

In this case, said route signal may be used to produce an indication of said route on said perceivable representation.

Said navigation system may preferably include audible signal means for using said route signal to provide audible information regarding said route. In this case, the audible signal means may be a speech synthesizer and said audible information is synthesized speeech.

Said desired position signal generating means are preferably provided on said perceivable representation, so that said perceivable representation of features of said area of the globe is perceivable by touch.

Preferably the display means comprises a surface whereupon

said represention and said indications are produced, said surface being alterable such that areas of said surface represent to the touch features of said area of the globe and another area of said surface represents to the touch said indication. These features may comprise routes.

The display means may comprise a plurality of pins arranged in parallel in a side-by-side array, each pin having a tip and the tips forming said surface, said tips being normally co-planar but being movable above said plane to form said representation and said indication.

The following is a more detailed description of an embodiment of the invention, by way of example, reference being made to the accompanying drawings in which:-

Figure 1 is a block diagram of a navigation system for blind persons,

Figure 2 is a schematic view of a display of the system of Figure 1,

Figure 3 is a partial view of an array of solenoid driven pins forming part of the display of Figures 1 and 2, and

Figure 4 is a schematic view of an FM radio data system providing real time position correction signals for the system of Figure 1.

Referring first to Figure 1, the navigation system comprises

an FM radio data system (RDS) receiver 10 having an antenna 11 and an output 12 connected to a global positioning system (GPS) receiver 13. This receiver 13 has an antenna 14 and an output 15 connected to a microcontroller 16. The microcontroller may take the form of a microprocessor.

A route-planning algorithm 17 has an output 19 to the microcontroller 16 and an input 18 from the microcontroller 16. An electronic map 20 has an output 21 to the control system and an input 22 from the microcontroller 16. An electronic compass 23 has an output 24 to the microcontroller 16.

The microcontroller 16 has an output 25 to a speech synthesizer 25 which in turn has an output 27 to a loudspeaker 28. Finally, a display 29 has an output 30 to the microcontroller 16 and an input 31 from the microcontroller 16.

The purpose of the system is to combine a global position signal with an electronically represented map to indicate the position of a person carrying the system on a map formed on the display 29. The map and the position can be felt so that they are usable by a blind person. The display can also indicate on the map the route between the current position of the person and a desired destination and, via the speech

synthesizer 26, can issue audible instructions and information. Other functions are also possible and all these will be described below.

The operation of the FM RDS receiver 10 and the GPS receiver 13 is shown in more detail in Figure 4. These systems are known per se. The global positioning system comprises a number of satellites orbiting the earth and producing position signals. In most parts of the globe, at least three of these satellites are always accessible at any one time. In Figure 4, the three satellites are referenced 32a,32b and 32c.

The position signals transmitted by the three (or more) satellites 32a,32b and 32c are received by the GPS antenna 14 and converted by circuitry in the GPS receiver 13 into a signal representing the position of the antenna on the surface of the globe. For security reasons, however, the signals from the satellites 32a,32b,32c are such that they may indicate the position of the antenna to an accuracy of tens of metres. In order to improve the accuracy, an FM differential correction is generated using the system shown to the left-hand side of Figure 4. This comprises a GPS reference receiver 33 having an antenna 34 and connected to a pre-processor 35. The output to the pre-processor 35 is connected to an RDS encoder 36 which is in turn connected to an FM transmitter 37 having a

broadcast antenna 38.

The antenna 34 to the GPS reference receiver receives the position signals from the satellites 32a,32b,32c. These signals are processed by the receiver 33 to produce a signal giving the position of the GPS receiver 33. This signal is compared with a signal representing the actual position of the reference receiver 33 (which is known because the position of the receiver is fixed on the globe) and a correction signal is generated which, after processing by the pre-processor 35, is encoded by the encoder 36 and transmitted over from the antenna 38 by the FM transmitter 37 as a side band signal.

This signal is received by the antenna 11 of the RDS receiver 10 of the display system. It is then passed to the GPS receiver 13 and used to apply a correction in real time or near real time to the position signal generated by the GPS receiver from the signals received from the satellites 32a,32b,32c. The corrected position signal is then outputted from the GPS receiver 13 to the microcontroller 16.

This signal may be in the form of latitude and longitude co-ordinates or in the form of an ordnance survey grid reference or in the form of co-ordinates in any other position system.

The electronic map 20 contains a representation of a specific area of the globe in the form of electronic data. It

will be appreciated that the data defining the map includes not only the elements necessary to form a representation of the map but also information regarding the elements (e.g. the identity of the elements and their relationship to other elements). This data will include data defining the position of each element in a co-ordinate system.

To overcome the limitations associated with the GPS (the multi-path effect and the loss of the GPS signals when system is used near tall buildings), the availability and the conditions of GPS signals for all the places (streets, roads, pavements, etc.) contained in the electronic map 20 would be checked by field trials, and the results would be stored in the system. By combining the availabilities of the GPS signals and some other information, such as the current walking velocity of the blind pedestrian (deduced from the latest movements), the system's microcontroller 16 would be able to take over the navigation function during the temporary loss of GPS signals by using dead-reckoning techniques and the route-planning algorithm 17 based on the electronic map 20.

The electronic compass 23 produces a set of signals which when fed into the microcontroller 16 represent the cardinal and intercardinal points of the compass.

The display 29 provides a perceivable representation of

features of an area of the globe contained within the electronic map 20. In the embodiment now to be described, this representation is perceivable by touch but this need not necessarily be the case.

Referring particularly to Figures 2 and 3, the display 29 comprises a plurality of pins 39 arranged in parallel in a side-by-side array. There may, for example, be 3500 pins arranged in an array of 50 pins by 70 pins.

As seen in Figure 3, the display 39 has three parallel plates, a lower plate 40, a middle plate 41 and an upper plate 42. The upper plate 42 has 3500 holes each aligned with a respective pin 39. The middle plate carries a plurality of shorter pins and the lower plate 40 carries a plurality of longer pins that extend through the plate 41 to the upper plate 42. The tips 43 of all the pins are normally level with the surface of the upper plate 42. However, each pin 39 has a solenoid 44 associated with the pin 39 that is actuatable by address lines (not shown) to raise the tip 43 of the pin above the level of the upper plate 42. Thus, by activating or de-activating the address line of each solenoid 44, the associated pin 39 can be raised above the level of the upper plate 42 or be dropped to be level with the upper plate 42 or can be repeatedly raised and dropped to vibrate the pins 39.

Referring now additionally to Figure 2, the microcontroller 16 produces from the electronic map data, signals that pass along the address lines and actuate the pins 39 to vibrate the pins to produce a pattern of vibrating pin tips 43 that provides a representation of features of the map. As shown in Figure 2, these features are thoroughfares such as roads and streets, although this may not necessarily be the case.

The microcontroller 16 also produces from the GPS receiver signal and the electronic map data, a signal along the address line to the solenoid 44 of the pin 39 that represents the current position of the system. The current position will be indicated by a down pointing arrow which is formed by a group of appropriate pins 39. In this way, the current position of the system (and thus of the user) can be readily felt on the map.

As seen in Figure 2, the pins 39 at the upper left-hand corner of the display 39 are fed with signals along their address lines by the microcontroller 16 from information provided by the electronic compass 23. The pins 39 are actuated to form an arrow 45 that indicates the position of north relative to the display.

It will be appreciated that, where the person using the system is familiar with the road system, an indication of the

layout of the roads and an indication of the position of the system will be sufficient to allow a person to find their way around the roads. As they move along the roads, the current position indicator (the down-pointing arrow) will not change on the display 29, but the positions of the features defined by the remaining pins will move accordingly.

However, where the person using the system does not know of the layout of the roads and where, as will often be the case, the roads are more complicated than as shown in Figure 2, the system can provide route information. This is done in the following way.

First, a required destination is chosen. This can be achieved by pressing the browse key on the display 29 and this will enable the microcontroller 16 to activate the speech synthesizer 27 and the loudspeaker 28 to output a series of destinations one after the other. Plainly, these destinations will be prestored in the microcontroller 16. The person can stop pressing the browse key 46 when a required destination is reached. When the desired destination is selected, an up-pointing arrow 55 appears on the display 29 showing the exact final destination.

When the microcontroller 16 knows a required destination, the co-ordinates of the current position of the system and the

co-ordinates of the required destination are passed to the route-planning algorithm 17. By comparing the co-ordinates of these positions and using topological analysis methods, a shortest route can be calculated avoiding, if necessary, features which blind persons find difficult such as roundabouts and roads carrying heavy traffic.

Once the route-planning algorithm 17 has determined this best route, this is passed to the microcontroller 16 which controls the solenoids defining this best route so that the pins 39 will be elevated to a fixed height and these pins will cease vibrating. In this way, the user can feel the desired route and travel along that route, with the current position of the user being indicated by the down-pointing arrow 54. If the user is unsure of the user's position then depression of any pin 39 wil give instant aural information via the speech synthesizer 27 and loudspeaker 28.

Each pin 39 may be designed to represent a distance of one metre on the ground so that an array of 3500 elements will represent an area of 50 metres x 70 metres. This utilizes the highest positioning accuracy of the output of the GPS receiver. However, the display 29 may be provided with a zoom-in key 47 and a zoom-out key 48. By use of the zoom-out key, the area displayed can be increased with the positional

accuracy of the current position being decreased accordingly. The zoom-in key 47 is used to return the display to its maximum sensitivity.

Given the size of the area that can be represented on the display 29, scrolling keys 49a,49b,49c,49d are provided on the display 29. One key 49a scrolls the map upwardly, one key 49b scrolls the map downwardly, one key 49c scrolls the map to the left of the display and one key 49d scrolls the map to the right of the display 29.

The control system 29 can be arranged so that the area displayed changes only when the current position (as indicated by the down-pointing arrow 54) is adjacent the edges of the display 29. Alternatively, however, the microcontroller 16 may be arranged so that the current position is always in the centre of the display, altering the display accordingly as the user moves. A key 50 may be provided which, if pressed, moves the current position to the centre of the display.

As indicated above, the electronic map 20 can contain data defining features other than topological features. For example, it can contain data giving information about features associated with the map. For example, this data could include descriptions of features to be found around each point on the map; for example, shops, churches, etc. It could also

include data regarding obstructions and other difficulties (such as kerbs) for blind persons.

This information can be accessed by the use of a direction information key 51, a current position information key 52 and a destination information key 53. Pressing the direction information key causes the speech synthesizer 26 to produce via the loudspeaker 28 information regarding the current direction. Pressing the current position information key 52 provides information about the current position of the user - for example, the identity of adjacent buildings. Pressing the destination information key 53 provides a series of instructions which guide the user to the chosen destination via the easiest route suggested by the microcontroller 16.

It will be appreciated that there are a large number of alterations that could be made to the system described above with reference to the drawings. For example, the display 29 need not be formed by the pins 39 and solenoids 44, it could, for example, be provided by some other tactile display such as a display using an electrorheological fluid. Such fluids have the ability to increase viscosity, even to the point of a semi-solid state, if an electric field is applied to the fluid. Accordingly, the map could be established by the selective application of an electric field

to areas of the electrorheological fluid to form a representation of features of the area that can be felt. Another possibility is to form the display from elements that can be either hot or cold so that the change in temperature can be felt. The display 29 described above with reference to the drawings is designed to be felt by the fingers but this need not be the case. In many blind people, other regions of the body's tactile surface are more sensitive than the finger tips and have the ability to detect information simultaneously. For example, the palms of the hands or the back have this ability.

The tactile display 29 and the associated keys may be replaced by a control handset which may look like a mobile telephone handset, and the speech synthesizer 26, the loudspeaker 28 and the control keys 46,51-53 would also be in this handset. In this case, only synthesized speech will be output to guide the blind persons, and only one hand of the user will be needed to control the system.

The electronic map 20 stores the data in a memory. It will be appreciated that data could be inputted into this memory from cartridges or other suitable carriers containing data defining a variety of areas.

It will be appreciated also that while the display described

above with reference to the drawings produces a tactile display, it also produces a visual display and the system could be used by the sighted. This could be of advantage, for example, where a person is in a town or city where they have no idea of the layout of the roads or streets. A similar system could be used to guide persons round a place of interest with information being given about the place of interest during the journey.

CLAIMS

1. A navigation system comprising a receiver for receiving a position signal transmitted thereto from a remote position signal generator, said position signal representing the instantaneous position on the globe of the receiver, and user interface means holding feature information regarding the spatial disposition of features of an area of the globe including said position, said interface means being connected to said receiver for receiving from said receiver a signal representative of said instantaneous position, and producing perceivable information derived from the spatial relation between said instantaneous position and at least some of said features of said area.

2. A navigation system according to claim 1 wherein said interface means provides a perceivable representation of the spatial disposition of said features of said area and wherein said production of said perceivable information comprises providing on said representation a perceivable indication of the spatial disposition of said instantaneous position.

3. A navigation system according to claim 2 wherein said interface means includes a display means on which the representation and the indication are provided, said representation and said indication being perceivable by touch.

4. A navigation system according to claim 3, wherein said interface means includes a memory means for storing electronic data representing the spatial disposition of said features, said interface means converting said electronic data into said perceivable representation on said display means.

5. A navigation system according to claim 4, wherein the interface means includes a control unit for receiving said signal from the receiver and said electronic data from the memory means, the control unit using said signal and said data to generate a control signal for controlling the display means whereby to produce thereon said representation and said indication.

6. A navigation system according to claim 4 or claim 5 wherein the system is adapted for producing on said perceivable representation a further perceivable indication indicative of the spatial disposition of a desired position lying on the globe spaced from said instantaneous position, a calculating unit being provided for producing from said signal from the receiver, said electronic data and from positional data representing the spatial disposition of said desired position a signal indicating a route between said instantaneous position and said desired position.

7. A navigation system according to claim 6 wherein the

route signal is used to produce an indication of said route on said perceivable representation.

8. A navigation system according to claim 6 or claim 7 including audible signal means for using said route signal to provide audible information regarding said route.

9. A navigation system according to claim 8 wherein the audible signal means is a speech synthesizer and said audible information is synthesized speeech.

10. A navigation system according to claim 3 or any claim dependent thereon wherein said display means comprises a surface whereupon said represention and said indication are produced, said surface being alterable such that areas of said surface represent to the touch features of said area of the globe and another area of said surface represents to the touch said indication.

11. A navigation system according to claim 10 wherein the display means comprises a plurality of pins arranged in parallel in a side-by-side array, each pin having a tip and the tips forming said surface, said tips being normally co-planar but being movable above said plane to form said representation and said indication.

12. A navigation system according to claim 1, wherein said interface means includes an audible signal generating means

and said perceivable information is an audible signal.

13. A navigation system according to claim 12, wherein the audible signal generating means comprises a speech synthesizer and said audible signal comprise sythesized speech.

14. A navigation system according to claim 12 or claim 13 wherein said audible signal comprise information for guiding a user from said instantaneous position to a desired position.

15. A navigation system according to any preceding claim, wherein the system is adapted for calculating, during said receipt of said position signal from said remote generator, the velocity at which the receiver is moving within said area, the system including dead-reckoning means for estimating using said velocity, the instantaneous position of the receiver during periods of use in which said position signal is not received by said receiver.

16. A navigation system according to claim 15, wherein the system is adapted for storing receivability data representing predetermined values of receivability of said position signal by said receiver at various locations in said area of the globe, the dead reckoning means being adapted for using said receivability data for said estimation of the instantaneous position.

17. A navigation system substantially as hereinbefore described with reference to the accompanying drawings.

21

Patents Act 1977 **Examiner's report to the Comptroller under Section 17** **(The Search report)**	Application number GB 9505478.9
Relevant Technical Fields (i) UK Cl (Ed.N) G1F, H4D (DSDA, DSDB, DSDX) (ii) Int Cl (Ed.6) G01C 21/20; G09B 5/06, 21/00, 29/10; G01S 7/04, 7/20	Search Examiner T S SUTHERLAND Date of completion of Search 18 MAY 1995
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE: WPI	Documents considered relevant following a search in respect of Claims :- 1-16

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X,Y	EP 0524814 A	(PIONEER) Figures 1 and 2, note speech synthesizer 17	X: 1, 2, 13, 14 Y: 3, 4, 6-10
X	WO 93/20546 A	(PARIENTI) note Claim 1	1, 2, 13, 14
X	WO 93/05587 A	(ETAK) whole document. An example of GPS combined with dead reckoning.	1, 2, 15, 16
Y	US 4570227	(TACHI) column 3 lines 16-19	3, 4, 6-10

Databases:The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).